Biologically Organized Quantum Vacuum and the Cosmic Origin of Cellular Life

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BIOLOGICALLY ORGANIZED QUANTUM VACUUM AND THE COSMIC ORIGIN OF CELLULAR LIFE

Abstract

We point out that the origin of life cannot be understood without a closer look at the nature of life. Therefore we present here, for the first time, ten fundamental biological facts opening new avenues to address the question of the cosmic origin of cellular life. We find that all living beings, including cells, have a genuine biological autonomy that acts with the help of spontaneous, physically indeterminate or arbitrary cellular decisions that initiate quantum effects in support of biological aims. We propose that these biologically initiated spontaneous processes are assisted by vacuum processes. A natural corollary arises, telling that biological processes organize the quantum vacuum processes of living organisms from below the physical level, which in turn strongly suggests that biology is more fundamental than physics. We point out that just as the functions played by the forwards in a well-trained football team cannot be assigned externally by a series of physical forces acting on the bodies of the football players, biological aims and functions cannot be attached to physico-chemical structures of the first cell of the Cosmos by merely physico-chemical processes, but must be assigned by a more general cosmic life form pre-existing before the first cell and containing it like mother its foetus. This would indicate that the Cosmos is not only the source of stars, galaxies, and cosmic clouds, but also of biologically initiated and organized cosmic “forces“ pre-existing in the vacuum and, ultimately, the Cosmic Subject.

I. Introduction

How can we fulfil our own human nature? How can we understand ourselves as living beings? How can we understand life from the viewpoints of science and philosophy? We find our life in a cosmic context. Basic questions are towering before us, posited by Nature, ultimate questions which, if left unanswered, then, as a result, our life can miss its genuine, original aim. These ultimate questions impress us human beings trembling from the same cosmic powers resonating within us throughout the life of the cosmic-minded species, the Homo Sapiens. We cannot escape from the powers of the Cosmos disquietening and intriguing us with ultimate, cosmic questions, arising from the creative forces of the Universe that form and drive the life of our innermost identity as it is given by Nature. Facing the cosmic questions of life, our mind becomes driven by cosmic forces arising from the ultimate openness of the Universe towards inner and outer

infinities. This ultimate openness of the whole of cosmic existence brings forth vast questions about our very human nature: What is the nature of life? What is the origin of life? In order to answer these ultimate, cosmic questions, we have to free ourselves from all prejudices and find the suitable, cosmic perspective in which we can we contemplate these ultimate cosmic questions impartially, learning from Nature by our best, Nature-given abilities. A first observation that we can obtain and learn by contemplating these two questions is that we cannot find the answer to the question of the origin of life without being aware of the relevant aspects of the nature of life, without having a closer idea what we are asking about.

1.1 Biological teleology

Before presenting a tentative list of the most basic problems of life, we have to say a few words about one of life's perhaps most characteristic and nowadays hotly debated property, teleology (Glasersfeld 1990, Wouters 2005). Recently, Kane (2002, 9) pointed out that due to the development of quantum physics, universal determinism has been in retreat in the physical sciences. At the same time, biology, neuroscience, psychology, psychiatry, social and behavior sciences have been moving in the opposite direction. In this conflicting situation the concept of teleology has played a central role.

It was not a scientist, but the socialist-journalist Marx, who exclaimed that Darwin dealt a "death blow to Teleology" (Dennett 1995, 126). There is a general belief that teleology is scientifically bankrupt, and that history shows it always has been. This belief is based on the widespread opinion that physics is incompatible with teleology (Russell 1946, Taylor 1964, 1967, Walsh 2000, Johnson 2006, 23-24, Illetterati and Michelini 2008, back cover); yet, as we will argue below, this claim can have only a limited validity, even in physics. It is important to keep in mind that there is also the widespread opinion that "it is now also popular, perhaps more so, to defend teleology" (Kreines 2009). There is absolutely no doubt that every effect in the universe can be explained as satisfying final causes, with the aid of the method of maxima and minima (the action principle), as it can from the effective causes (Euler 1744, cited in Lemons 1997, x). The action principle represents the contemporary descendant of final causes. (ibid.). Actually, opponents of the least action principle have expressed a hostility toward introducing the concept of teleology into physics, for this notion has usually served as a wedge to infiltrate religious and metaphysical ideas into what should be a purely physical discussion (Barrow and Tipler 1986, 150). Nothwithstanding, Barrow and Tipler (ibid., 123-218) have shown that, on the contrary, teleology has on occasion led to significant scientific advances.

We point out that the rejection of genuine, teleological biological function has, in a certain context, its own but limited scientific basis. As the Encyclopedia Britannica tells (in its entry "action"): Motion, in physics, may be described from at least two points of view: the close-up view and the panoramic view. The close-up view, describing motion by differential equations, involves a local, instant-by-instant charting of the behaviour of an object. The differential equations are statements about quantities localized to a single point in space or single, instantaneous moment of time. By contrast, the action principle is not localized to a point; rather, it involves integrals over an interval of time and (for

fields) an extended region of space. The panoramic view, offered by the action principle, reveals not only a complete picture of the actual behaviour of an object but also all the possible routes of development connecting an initial situation with a final situation. Each route between the two situations is characterized by a specific numerical quantity called its action. The principle of least action states that for "small" variations of the paths, the end points being fixed, the action S is an extremum, in most cases a minimum (Brown 2005, xiv). Teleology is defined in the Encyclopedia Britannica as "explanation by reference to some purpose or end". The fixing of the final state gives the action principle a kind of teleological character, since the motion of a physical system is determined in the action principle formulation by both the initial and the final states of the system (Barrow and Tipler 1986, 149).

Importantly, all the fundamental laws can be derived from the least action principle, including Newton's equations, the wave equation, the diffusion equaton, Poissson's equation, and each of Maxwell's, Einstein's and Schrödinger's differential equations. General relativity and quantum mechanics both originated from variational principles (Lemons 1997, 111). Depending on the actual branch of physics, the content of the Lagrangian function characterizing the interactions of the system and the auxiliary conditions will be different. The basic textbook of physics serving for university students worldwide, written by Landau and Lifshitz (the famous ten-volume Course of Theoretical Physics series, 2000), is based on the least action principle as the core idea. The action principle turns out to be universally applicable in physics. All physical theories established since Newton may be formulated in terms of an action. The action formulation is also elegantly concise. The reader should understand that the entire physical world is described by one single action (Zee, 1986, 109). It is a widespread view that the least action principle is equivalent with the fundamental physical equations. We note that in an important sense, the equivalence is not complete, since teleology is not present at the level of fundamental differential equations. Therefore, in the narrow picture of physics containing only the physical conditions plus the differential equations of physics, teleology is, indeed, not present, and this gives an apparently irrrefutable scientific basis for the opinion that all forms of teleology must be excluded from physics. Yet if we step out from this narrow picture, we can work in a more complete conceptual framework of physics, in which the least action principle is also available as an explanatory tool, then teleology is actually present in a specific, mechanical form that is fundamentally different from genuine biological and human teleology.

Even acknowledging the endpoint-oriented, teleological character of the least action principle, there is strong resistance to accept this teleology as real, and, consequently, many consider this teleology as being only 'apparent'. The popular attitude against teleology led scientists to regard the least action principle as 'puzzling' because of its 'seemingly' teleological quality: Given a set of initial and final conditions, one is able to find a unique path connecting them, as if the system somehow 'knows' where it's going to end up and how it's going to get there. We point out that this opinion arises from confusing physical, bological and human teleology, which, actually, have a fundamentally different nature. Certainly, elementary particles do not 'know' where to go in the same way as some of us human beings know. The path integral method, worked

out by Feynman (1942, 1948, 1964, 1994) offers a kind of explanation in terms of quantum superposition as to why the least action principle works so similarly yet differently than the way we humans do. The system (for example, a photon in the two-slit experiment) explores every possible path to any possible endpoint with the help of virtual particles that are freely created from the quantum vacuum, and the path integral simply calculates the sum of the probability amplitudes for each of them. Interference effects guarantee that only the contributions from the stationary points of the action give histories with appreciable probabilities, and the most probable path corresponds, remarkably, just to the least action. The system does not have to know its endpoint in advance, as a human being has to know where to go, since it does not have to decide about its path, because the physical path arises without the active contribution of the system. Therefore, it may seem that the least action is the result of a simple and mechanical summation of the probabilities of all paths. Yet these probabilities themselves were calculated on the basis of the least action principle (with the help of equations derivable from it). Definitely, the process is similar to a human decision process in which the first phase corresponds to exploring all the possibilities, and the second phase to sum them up, weighed up by our own principles of evaluation. With this addition, Feynman's argument makes it clear for us why and exactly in what respect physical teleology is different from the human one. Physical teleology — although the reference to the end is explicit — is not apparent, but automatic and mechanical; the endpoint is determined not by the system (as in the case of a human being) but by the initial (and boundary) conditions on the basis of physical laws. We emphasize: The physical system is passive in this respect, it does not contribute to determine its endpoint.

We point out that in biology the case is already different. All living organisms, from cells to plants, animals and humans, actively contribute to maintain their lives, flourish, and determine their biological processes (most biologists accept teleology in biology, see e.g. Ruse 2012). As we will see below (section F4), a kind of teleology different from the mechanical, physical one is a basic fact in biology. An example may be helpful to shed light on the difference between physical and biological teleology. A stone falling from the Pisa tower cannot contribute anything to the selection of its endpoint. In comparison, a living bird dropped from the same height actively contributes to select the endpoint of its trajectory, unlike a similar but dead bird, which cannot. Definitely, living organisms could not maintain their life if they could not contribute to the determination of their structures, functions and processes. Teleology is ubiquitous already at the cell's life. Indeed, "little occurs in the cell on the basis of chance" (Agutter, Malone, and Wheatley 2000). For example, hormones, neurotransmitters, and other signals must be directed towards their receptors; and if so, then these processes are, by their very nature, actively teleological, endpoint-oriented, since the living cell actively determines their endpoint (Kawade 1992, Grandpierre 2012). Usually, a neurotransmitter must reach a suitable receptor. Otherwise the experience of pain elicited at the end of our finger from a candle flame burning it would not be able to transmit the sign to our brain and back, so that we may withdraw our finger away from the fire. Extending Feynman's argument, we propose that in biology an extended version of the action principle is at work, namely, the greatest action principle (Grandpierre 2007). By our proposal, in a living organism, virtual particles also map the whole situation, exploring every possible trajectory, like in

the case of the least action principle; but in the case of a living organism, the organism actively contributes to determine the endpoints of its biological processes on the basis of the generalized action principle, the greatest action principle. The organism selects the outcomes corresponding to the greatest action, since this is the path securing the most energy for the longest time period — that is, the greatest action. Yet there is potentially a large number of biologically equivalent solutions, each satisfying the greatest action principle and the biological functions in an equal rate. Therefore living organisms must be acknowledged as actively contributing to the selection of the actual path of their biological processes. This biological selection process does not involve human-like self-consciousness, since in it the natural principle of greatest action plays the determinative role, and the contribution of the organism is, usually, only complementary, secondary, selecting from biologically quasi-equivalent versions.

Such a genuine biological teleology is obscured not only by the widespread, but, as we argue here, unsound opinion claiming that every type of teleology is excluded by physics; but also by confusing biological teleology with an even more familiar but fundamentally different kind of teleology, namely, the teleology characteristic to self-conscious beings, humans. Human beings have the ability to recognize conditions and foresee the consequences of their actions initiated by their free will (Kane 2002, Brembs 2011). (Regarding the free will debate, see Clarke 2008, Doyle 2011). It is important to note here that recently the existence of free will became experimentally demonstrated. In two novel experiments Cerf and Mackay (2011) had shown that subjects are capable of overriding external sensory input with internal imagery, and can directly control the firing rate of individual neurons in the medial temporal lobe. Human teleology manifests itself in self-conscious, representational control, planning and careful, responsible realization of human purposes — a process in which individual contributions become dominant.

2. A set of fundamental biological facts and problems

We present here, for the first time, ten basic biological facts (facts 1–10, shortly F1–F10) transcending the present conceptual framework of biology. We point out that in the last decades biology has reached a turning point and we need to re-evaluate the theoretical framework of the nature of biological autonomy, aims and functions.

<u>F1. Biological aims/Functions.</u> A cell cannot be alive if its proteins could not have their functions, like defense against germs, facilitation of biochemical reactions, coordination of activities, storage, synthesis and transport of biomolecules, bodily movement, or structural support. Let us define biological functions as coherent systems of biological processes serving biological aims, ultimately, the survival and flourish of the organism as a whole. Two types of such functions may exist: i) biologically completely determined (assuming there really are any biologically completely pre-determined phenomena, such as, perhaps, digestion); and ii) incompletely pre-determined (e.g. problem-solving) ones. Incompletely pre-determined functions correspond to biological autonomy. Again, we find ourselves in a conflicting situation. On the one hand, as the entry "biology" in the Encyclopedia Britannica (Green 2012) states, living organisms cannot exist without

biological functions: “Living things are defined in terms of the activities or functions that are missing in nonliving things.” Accordingly, it has been argued that “‘Nothing in biology makes sense, except in the light of teleology’. This could be the first sentence in a textbook about the methodology of biology” (Toepfer, 2011). In living organisms, very special structural changes are permanently produced that as boundary conditions harness the material forces (quantum mechanical-obeying forces) to the purposeful pursuits of organisms (Strohman 1997). On the other hand, there is strong resistance to the idea of a genuine biological teleology in principle, based on the objection that the very idea of biological function seems to be inconsistent with the conceptual scheme of physics: “The biological concept of function appears teleological, implying goal directedness or purpose…. Ever since the scientific revolution, however, teleology has become exiled from science” (Buller 2002, 393). We note that the reason beyond this argument is that teleology has appeared inconsistent with deterministic physical equations. Here is the problem to be solved: how to make teleological functions compatible with present-day physics? We point out that teleology cannot arise from physical conditions and laws, since it represents a fundamentally different type of causation. The resolution of this fundamental problem directs us not only to a generalized action principle, the endpoint of which can be determined biologically (Grandpierre 2007), but also to the indeterminacy of quantum physics. Actually, genuine biological determinations can act only on physically indetermined, that is, quantum processes. This means that *it is quantum indeterminism that may open the possibility for the physical realzation of biological aims*.

F2. Functions/Quantum indeterminism. In a heap of radiactive material, parcels of matter are interchangeable. In a living organism, different organs or limbs are not interchangeable. Within quantum physics, the chances of physically undetermined processes average out. This is to be expected when all subsystems are independent. Yet in the case of living organisms, evidently subsystems are highly dependent on each other in a specific manner that makes the life of a highly complex, composite being possible. *Therefore we have an objective basis to consider the proposition that, with respect to biological functions, the chances of different, physically undetermined microprocesses can be systematically changed and utilized for realizing the biological aims of an organism in a physically arbitrary, that is, not a physically completely pre-determined manner.*

F3. Functions/Machines. There are no natural machines. Complex machines cannot arise from spontaneous physical processes. The construction of machines cannot arise from an initial state as a result of random accidents and physical determinations, since the function of any machine requires a consequent series of physically arbitrary steps. On the basis of random physical processes, the chances of selecting any of the exact individual steps suitable for building up a machine are infinitesimal; their joint occurrence in the right order would be exponentially improbable. Similarly, if all you have to go on is what physics allows, the individual steps building up a machine by an engineer are extremely improbable, and their occurrence together in the right order would be exponentially more improbable if the engineer himself can work only with entropic processes. This means that the engineer’s actions in constructing a machine cannot be completely determined by physics; therefore, the decisions reifying these actions must be physically arbitrary.

F4. Functions/Gratuity. The same eleven human being can form in the same spatial arrangement a football team, an orchestra, a crew of sailors, or a family club, depending on their internal focus of attention. At variance with machines, the same living organism in the same situation can behave in many different ways. This means that the material structure of a living organism does not determine completely the biological behavior. The description of a behavior belongs to a logical type of a greater order than the description of a structure (Nobili 1997, 7). This means that until decisions about the biological behavior did not occur, structure does not determine function. Defining functions as aim-oriented organized systems of biophysical processes serving the survival and flourish of the organism as a whole, we can observe that such a type of logical relations between parts and wholes are completely missing in physics.

Physically arbitrary phenomena occur not only in quantum theory and at the construction of machines, but also in biology. Jacob and Monod (1961) discovered that there is no chemical necessity about the chemical composition of the molecules regulating the functions of allosteric enzymes; e.g., which inducers regulate which genes (see also Monod 1972, 78). "On such a basis…it becomes possible for us to grasp in what very real sense the organism does effectively transcend physical laws — even while obeying them" (ibid. 80). The structure and function of a molecule (of protein or any other substance) are associated with each other, with various degrees of arbitrariness, as are the content and expression of a sign in general. Namely, the activities or the sign functions of biological molecules are determined by the organized system they belong to, and not vice versa (Kawade, 1992). The bridge between genes and proteins was provided by molecules called adaptors (transfer RNAs) that have two recognition sites: one for a group of three nucleotides (a codon) and another for an amino acid. The crucial point is that the two recognition sites are physically separated and chemically independent. There is no deterministic link between codons and amino acids, and a one-to-one correspondence between them could only be the result of conventional rules (Barbieri 2008). A sign is a sign only when it stands for something that is other than itself, and this otherness implies at least some degree of independence (Barbieri 2008). It can represent something else only if it is able to step out of its immediate physical determinations. Similarly, Maynard-Smith (2000, 193) observes that there is no physico-chemically necessary connection between the form (chemical composition) and regulatory function (genes switched on and off) of proteins. Moreover, there is no chemical necessity between biochemical structures and their biological functions (like those of hormones). The same chemical structure (of e.g., adrenaline) could, in principle, raise blood pressure or decrease it; the connection between its chemical and biological properties is, in this sense, arbitrary.

The physically arbitrary nature of biological functions is made more remarkable in light of models depicting self-organizing networks that lead to emerging global patterns without apparent corresponding function (Keller 2007). Designing models with externally assigned functions is a procedure too arbitrary to explain the systemic properties of biological phenomena (Krohs and Callebaut 2007). "In biological systems self-organization is a process in which pattern at the global level of a system emerges solely

from numerous interactions among the lower-level components of the system. Moreover, the rules specifying interactions among the system's components are executed using only local information, without reference to the global pattern" (Camazine et al. 2003, 8). Now functions by their very nature refer to the global level of the living organism (Beckner 1969: „Functional ascriptions describe the role played by a part or process in the activities of a larger or more inclusive system"). Therefore it is clear that physical self-organization is not suitable to explain biological functions. We note that the following problem needs to be resolved: A biological aim as such is teleologically given by the organism, stepping out from its immediate physico-chemical determinations; thus it cannot arise from physical processes. Given that insight, we arrived to a basic problem: what kind of process assigns functions to biomolecules? The next problem is: How can physics account for "things" so alien, unobservable and theoretically undescribable by physics such as biological aims? And how do such unobservable "things" become, however, perceived, understood, decided about and realized in the physical form of a function? Moreover, regarding the set of biologically useful functions as a tiny subset of all possible (useful and non-useful) functions, an additional question surfaces: How do all the many thousands of teleological biomolecular functions (which are necessary for an individual cell to exist and function) arise? To answer that question by reference to one or more "frozen accidents" in the history of inanimate matter on the Earth (Crick 1968) is not only insufficient but misses the point: Frozen physical accidents cannot assign biological functions to physico-chemical structures.

F5. Functions/Organized Complexity. All living organisms interact with a complex environment that is indefinitely rich in unexpected challenges. Therefore, all organisms must continuously solve newly encountered problems in their daily lives. Such an achievement requires the internal generation of new algorithmic information (Grandpierre, 2008a), corresponding to new biochemical structures serving newly created aims. This means that already the smallest living organisms, the unicellular organisms, are not machines. They can't be machines, since they act as their own engineers, spontaneously generating their own aims and functions, continuously re-engineering their internal structures in a biologically suitable manner. Accordingly, numerical estimations indicate that a significant part of the thermodynamic potential of cells is utilized in order to generate new information (ibid.). The complexity of living organisms has not only static, but also a systematically varying component.

F6. Creativity/Lawful variability. Life is by its very nature a creating power. Despite of this basic fact, it is usual to consider that living organisms are like physical machines, just much more complex (Vogel and Angermann 1984, 1) and their complexity is unfathomable (ibid.; Hempel 1966, 101). In the physicalist bottom-up approach such an unfathomable and time-variant complexity is considered contingent and thus cannot be described. In contrast, an approach searching for the universal law of biology has been successful: The fundamental principle of time-variable biological complexity has already been formulated by Ervin Bauer (1935/1967). He was able to derive all the fundamental life phenomena from the mathematically formulated version of his principle (ibid.; regarding biological laws, see also Beloussov 2008).

F7. Control by Information. Life is based on information processing (Hoffmeyer 1997; Maynard-Smith 2000; Mayr 2004; Ben-Jacob, Shapira and Tauber 2006; Shapiro 2009; Binder and Danchin 2011). We point out that it is a fundamental problem how does the static information content of e.g. the DNA can be transformed into the continuously changing information that directs the time-dependent *dynamic behavior* of material molecules (Grandpierre, 2008a). At all levels of analysis living organisms from the global to the molecular level represent high-information-content (low thermodynamic probability) entities. So far as their internal dynamics is concerned, most biochemical processes are channeled or "directed" rather than random processes, which further suggests that little occurs in the cell on the basis of chance or as a simple consequence of the law of mass action (Agutter et al. 2000). There is nothing random about the assemblage of a bacterial cell (Harold 2001, 10). The great irony of molecular biology is that it has led us inexorably from the mechanistic view of life it was believed to confirm, to an informatic view that was completely unanticipated by Crick and his fellow scientific pioneers (Shapiro 2009). It is the cell as a whole that is an active agent utilizing and modifying the information stored in its genome (ibid.). How the cell as a whole can act on its parts is a fundamental problem, the solution to which leads necessarily to the extension of the conceptual framework of biology beyond that of physics.

F8. Qualia/Subjectivity. Cogito, ergo sum – I think, therefore I am, as the famous saying of Descartes formulates. All our knowledge arises from our personal experiences. All objective physical properties such as mass, form, color, temperature, pressure of physical bodies observed through our outer senses, originate from subjective perceptions of these phenomena. Despite this genetic connection between subjectivity and objectivity, physicalism *ab ovo* rejects the concept of "subjectivity." Qualia, the subjective experience of phenomenal qualities, are utterly expunged from the objective viewpoint of physics (Chalmers 1996, 4). As Thomas Nagel formulated in his famous essay „What it is like to be a bat": Instead of grasping the concept of subjectivity, physicalism rather seeks to sidestep it. Thus the theoretical background of the "subjective" is missing (Nagel 1974). Every subjective phenomenon, however, is essentially connected to a single, first-person point of view. And it seems inevitable that an objective, physicalist theory cannot accommodate such a point of view. „The problems raised by subjective consciousness are perhaps the most baffling in all philosophy" (Dawkins 1998, 283). In biology, the subject is given in the form of the biologically autonomous living organism. It is biological autonomy that creates biological aims, functions and realizes them. Therefore biological autonomy can be regarded as the first scientifically exact formulation of the 'subjective', or consciousness itself. If genuine biological autonomy exists, as we argue in this paper, then this is a concept that can open a perspective towards developing the first comprehensive scientific theory regarding this subject. In quantum physics, the subject enters as the 'observer'. In this way, a plausible new idea arises for us, namely, to extend quantum physics to biology. Indeed, it is already indicated that the new biology will be a more general science than quantum physics (Wigner 1969; 1970; Grandpierre 2007; Josephson 2012).

F9. Cellular intelligence/decision making. It is well known that the rate of self-conscious information processing of the human brain as a whole, when measured in bits/sec, is

around 1-100 bits/sec. Since our brain consists of cca. 10^{11}-10^{13} neurons, this yields an average rate for the self-conscious information processing as 10^{-11} bits/sec/neuron. In comparison, neurons of the visual system process an information rate of cca. 3 bits/sec/neuron (Anderson, van Essen and Olshausen 2005). The intrinsic activity of the cells is estimated to process roughly 10^6 bits/sec/cell (Grandpierre 2008a). Therefore, cells process information not only in a biologically appropriately (Ganesan and Zhang 2012), but in a rate that is cca. hundred quadrillion (10^{17}) higher than that of human self-consciousness. Indeed, self-consciousness represents only an infinitesimal fraction of our ability to process information (Norretranders 1998). This means that our cells manifest a remarkable degree of intelligence.

The phenomenon of cellular intelligence seem to be not widely known. Notwithstanding, the topic of "cellular intelligence" has a rapidly growing literature (Quevli 1917; Albrecht-Buehler 1980, 1985, 1990, 2005, 2009; Mathieu and Sonea 1996; di Primio, Muller and Lengeler 2000; Ben-Jacob, Becker, Shapira and Levine 2004; Ford 2004, 2006, 2010; Hellingwerf 2005; Ben Jacob, Shapira and Tauber 2006; Shapiro 2007). Cells can demonstrate both anticipatory and contemplative behavior (Tanaka and Nakagaki 2011). Bacteria are shown to be able to solve newly encountered problems, assessing the given problem via collective sensing and recallable stored information of past experience, as well as solving optimization problems that are beyond even what individual human beings can readily solve (Ben-Jacob 2009). They can generate new genes that allow the bacteria to cope with new environments (Ben-Jacob, Shapira and Tauber 2006). The ability to assign contextual meaning to externally gathered information is a fundamental semantic function of natural intelligence that every organism must have (ibid.). Bacterial chemical communication also includes assignment of contextual meaning to "words" and "sentences" (semantic/syntax functions) and conduction of ''dialogue'' (ibid.). With regard to bacteria, semantics would imply that each bacterium has some freedom (plasticity) to assign its own interpretation to a chemical signal according to its own specific, intercellular state and external conditions (ibid.). Cells can perceive self and group identity and act accordingly to self and group aims (Ben-Jacob, Becker, Shapira and Levine 2004), sense their external and internal environment (Ben-Jacob, Shapira and Tauber 2006, 514), and monitor their internal states (Shapiro 2009, 9). Cells demonstrate the capability of collecting and integrating a variety of physically different and unforeseeable signals as the basis of problem-solving decisions (Albrecht-Buehler 2009). They can respond and make biologically useful, efficient decisions (Linder and Gilman, 1992; Strome and Lehmann 2007; Ngalim, Magenau et al. 2010; Sanges and Cosma 2010; Hyduke and Palsson 2010; Ford 2004, 2006, 2010; Balazsi et al. 2011; Bandyopadhyay et al. 2011). Decision-making is a central feature of the cell (Shapiro 2009). Although Ben-Jacob (2003) and Ben-Jacob, Shapira and Taubner (2006) seem to suggest that bacterial freedom is related to physical self-organization, we emphasize that physical self-organization is a physically determined process, while bacterial behavior is based on physically indetermined processes. Concretely, it is the cell itself that makes decisions about cellular processes. It is widely agreed that the phenomenon of play requires freedom (Hughes 2003; 2010, 4-5). Therefore, it is important that play is manifest in animals (Brown and Vaughan 2009, 23), plants (Mancuso 2010), and it is suggested to extend from cells to the Universe (Brown

and Vaughan 2009, 37-38). *The chemical forms are utilized as symbols that allow the cell to form a virtual representation of its functional status and its surroundings* (Shapiro, 2009). Any successful 21st century description of biological functions will include control models that incorporate cellular decisions based on symbolic representations (ibid.). We point out that since all organisms are either cells or build up from cells, the ability of the cells to act according to their aims and to make spontaneous decisions with the help of biologically meaningful symbols representing their functional states and their surroundings while transcending physical determinations means that all living organisms are autonomous.

<u>F10. Quantum physics/Observer problem</u>. Dirac (1927) remarked that the 'freewill' of the observer seems to play a crucial role at the preparation phase of measurement (Bacciagaluppi and Valentini 2006, 188, 493). Von Neumann (1955, 351) demonstrated that the action of the observer is physically undetermined, arbitrary (see also Bishop 2011). We also have Wheeler's (1978, 14) famous saying, which states: "No phenomenon is a phenomenon until it is an observed phenomenon". If so, the physically arbitrary observer–observed relation has a fundamental significance, leading to the idea of a participatory Universe in which the observer participates in creating the observable Universe (Wheeler 1981, Kafatos and Nadeau 2000).

Now let us summarize these fundamental findings. On the basis of the facts showing the existence of cell intelligence (F9), and keeping in mind the arguments presented above as well, we can realize that the cell as a biological entity has the ability to observe and represent its internal states in a symbolic form and to initiate biologically useful changes. On the basis of facts referred to in F1, F4, F8, F9 and F10, we propose that these biologically initiated cellular changes utilize quantum effects. Such spontaneous, physically indeterminate or arbitrary cellular decisions that initiate quantum effects assisting biological aims will be called here as quantumbiological interventions. We can realize that F1 corresponds to functions, teleology, and biological aims; F2, F3, F5, F6 and F7 to complexity; F9 to autonomy, F3, F4, F8 and F10 to arbitrariness; F1, F4, F8, F9 and F10 to a quantumbiology that is more fundamental than physics. We note that the physically arbitrary character of biological processes assigning function to material carriers (F4); the ability of cells to make intelligent decisions on the basis of symbolic representations (F9); the necessity that the cell must assign a certain kind of teleology to its processes (F1); the physically arbitrary nature of the subject's actions (F8); and the relation between the subjective nature of the observer and the objective nature of the observed (the observer "intends" what is to be observed) can be traced back to a common basis. We propose that the common basis is that biologically initiated, physically spontaneous decisions exert their determinative power through quantum processes in the context of their extremely high and time-variable complexity (F2, F3, F5, F6, F7). Physicists' measurements are indirect observations of quantum processes, amplifying them into observable macroprocesses. In contrast, biological quantum interventions correspond to the cell's observation of its own microprocesses directly. These observations serve as the basis for cellular decisions that are then transformed, through quantum effects, into macroprocesses, changing the macroscopic behavior of the cell. Therefore, while physical measurements yield indirect output data about microprocesses,

quantumbiological interventions produce input and boundary conditions to the cell's global control of microprocesses, modifying them into a form suitable to serve a time-variable output fulfilling biological aims.

It is a popular idea that quantum mechanics is a complete theory and so it must be capable of explaining biological phenomena. In contrast, we point out that, in the absence of guidance by measurements or observations, the time development of the wave functions is either determined by the Schrödinger equation, or changes randomly due to vacuum fluctuations that average out. Yet, as we can see from F1-F10, the fulfilment of basic biological aims requires biological determinations transcending physical determinations and randomness. This means that the assumption of the adequateness of quantum physics with respect to biological phenomena is in sharp contrast with the ten basic biological facts presented above. Similarly to the insufficiency of classical physics to explain quantum phenomena, quantum physics is unable to explain genuine biological phenomena. We find that biology represents a deeper layer of Nature, beyond the level of the quantum vacuum: The development of science must proceed along the line exploring how quantum physical processes are organized in living organisms.

3. The Origin of Life in a New Light

At present, the dominant view of the origin of cellular life on Earth is abiogenesis (Ricardo and Szostak 2009; Panno 2010, 20). Yet the theory of abiogenesis completely leaves without account the genesis of first cellular *functions as such*; and, as Davies (2006, 300) has said, the origin of life in such approaches remains "a completely unexplained bonus".

3.1. Biological meaning is assigned to biochemical structures

Recently, Barbieri (2008) has shown that three basic ideas of modern biology — namely, (i) the model of the cell as a biological computer made of genotype and phenotype; (ii) the physicalist doctrine that everything in life must ultimately be accounted for by physical quantities; and (iii) the idea that all biological novelties have been brought into existence by natural selection — are already ruled out by experimental facts. In short, the genesis of biological meaning — i.e., biosemiosis — is not only a fact of life but is 'the' fact of life that allows life to emerge from inanimate matter. Biological teleology, as we have shown in F4, cannot arise from physical conditions on the basis of physical laws. But can it arise spontaneously in a physical process, in an extremely rare random 'accident' at the early Earth, as generally assumed? *We argue here that biological teleology cannot arise from physically pre-determined and spontaneous physical processes since such processes cannot attach a biological function to biochemical structures.* We point out that the physical production of a protein means only the production of a molecule having the same chemical composition as that of a 'living protein' that already has one or more biological functions assigned to it. Since biological functions, such as the defense of the cell against germs, cannot be produced in a physical process, it stands to reason that a yet functionless protein produced physico-chemically to obtain an ingredient for the first cell in the abiogenetic picture, cannot be a biologically

useful protein. We conclude that the 'cell' consisting from such functionless ingredients cannot be viable.

The case is similar to the case of a football player who has a function, for example, to play the role of a goal-oriented forward. Forwards, also known as strikers, are the players on a team in association football who play nearest to the opposing team's goal, and are therefore principally responsible for scoring goals. In order that proteins can work in a biologically useful manner for their host cell, they cannot work on the basis of their chemical affinities. They must be driven by information. But in the linear sequence of base pairs of the DNA only a static information is present. Yet at the same time, the protein is expected to act dynamically, driven by forces governing their position, conformational state, energetic and electronic states. And this dynamism, within the physicalist picture, must be driven by physical forces. Yet it is impossible to plan a machine that could exert a series of physical forces to the body of the forward in order to guide its behavior successfully for the football team. Similarly, it is impossible to realize any physico-chemical structure that could exert just the required series of physical forces on the structure of the protein in order to fulfil its biological function, such as defense against germs. This means that in order for the first cell to be viable, all the necessary biological functions must already have been assigned to its biomolecules. In the hypothesis of abiogenesis, such a process is missing. Even if we assume that the first cell in the cosmic genesis of life by good luck possesses all the necessary ingredients just in the right place and in the right shape formed spontaneously in a purely physical process, any such first cell would not be viable, since its biomolecules would not have acquired any biological functions, since all what happened is simply a series of purely physicochemical processes.

Our argument shows that the biological control of living cells cannot be realized by physically governed conditions acting on biomolecules. This means that a physically uninterpretable entity like a biological aim must act as a determining factor within the process of attaching a biological fiunction to certain physicochemical structures. As Abraham Maslow once noted (1966, 15), "I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail." Now, in the light of our argument above, we think it is obligatory to allow that Nature may employ a tool yet to be acknowledged by mainstream science; and that this very tool, in conjunction with effective physical forces, is what gives rise to biological teleology, as represented by biological aims and the functions serving them. This natural tool will be identified below later on.

Our result tells it is not possible to determine the function of a protein, for example, to defend the cell from bacteria, in a physical process. The assumption of abiogenesis rests on the ground that once the suitable physicochemical structures of the first cell are formed, their biological functions are automatically attached to them. Our argument presented here shows that such an assumption lacks a suitable physical basis.

3.2 Fundamental role of life in the Universe

There is an increasing number of scientists recognizing the fundamental role of life in the Universe. The anthropic principle (Barrow and Tipler 1986) tells that 'our location in the Universe is necessarily privileged to the extent of being compatible with our existence as observers'. Moreover, there is the oft-repeated claim nowadays that life is 'written into' the laws of nature (Davies 2003). There is now broad agreement among physicists and cosmologists that the universe is in several respects 'fine-tuned' for life. This claim is made on the basis that existence of vital substances such as carbon, and the properties of objects such as stable long-lived stars, depend rather sensitively on the values of certain physical parameters, and on the cosmological initial conditions. There are many facts indicating that the universe is 'biophil' (Rees 2001) or 'bio-friendly' (De Duve 1995). Shapiro (1986) refers to the idea of optimal biophilicity of the universe as 'biological determinism'. It is the assertion that life will be almost inevitable given earth-like conditions. The three main schools that interpret biological determinism are assuming either the probability of the origin of life is extremely enhanced by autocatalytic cycles (Eigen 1992, vi), or by self-organization (Kauffmann 1995, vii) in open, far from equilibrium systems (Grandy 2008). Yet we point out that all of these mechanisms represent physical determinations, and as such are incapable of giving an account of genuine *biological* phenomena. As we pointed out on the basis of Bauer's principle (Bauer 1967, Grandpierre 2008b), it is the most basic characteristic of biological processes that they deviate from the ones expected within the given physical conditions on the basis of physical laws from time step to time step, mobilizing all their internal energy resources against the equlibration processes that should occur on the basis of physical (physico-chemical, thermodynamic, quantum physical, etc.) laws.

Recently, Davies (2006, 300) wrote that the bio-friendliness of the universe may arise from an overarching principle that constrains the universe to evolve towards life and mind. It has the advantage of 'taking life seriously', treating it neither as a completely unexplained bonus, as in the popular physicalist picture of abiogenesis; nor as a passive selector, as in the theory of 'multiverse', in which infinitely many 'universes' exist and we just happen to live in the one suitable for life. The apparent disadvantage of the life principle, in the opinion of Davies (2006, 300) is that it introduces "teleology that represents a decisive break with traditional scientific thinking, in which goal-oriented or directional evolution is eschewed as anti-scientific." We note that explaining the biggest unsolved problems of science - among them the existence of biological teleology - might require, indeed, a thorough revision of some deeply ingrained traditional assumptions. Moreover, as we argued in Section 2 (Biological teleology) of this paper and elsewhere in more details (Grandpierre 2012), there are different types of teleology (physical, biological and psychological) which are not to be conflated or confused. Additionally, a crucial circumstance in favor of the life principle is that it has already been formulated in a mathematical form (Bauer 1967, Grandpierre 2007), and all the fundamental life phenomena can be derived from it (Bauer 1967). We think that these fundamental facts will be useful establishing the life principle — as first formulated by Ervin Bauer, the Hungarian-born biologist — firmly in modern science.

It is important to observe that cosmic evolution — the idea that the universe and its constituent parts are constantly evolving — has become widely accepted in the last 50

years (Dick 2009). In the last decades, it has become increasingly clear that biological (and cultural) evolution has been an important part of cosmic evolution on Earth, and perhaps on many other planets (Dick and Lupisella, 2009; Davies 2009). Indeed, Davies (2009, 383) presents arguments showing that the long-held prevailing view claiming that living systems have no particular significance in the cosmic scheme of things is "profoundly wrong". Biological organisms are a product of a very basic organizational principle even in the Darwinian theory of evolution — replication with variation plus selection, a principle that applies anywhere in the cosmos. Moreover, the ability of living organisms to construct a computational representation of the universe makes them capable of manipulating their environment on a large scale. Therefore, "life (…) and mind is a key part of the evolution of the universe" (ibid.).

3.3. Biology is more fundamental than physics

As Tymieniecka (2011, 4) recently indicated, Heraclitus claimed that flux is more basic than stasis. This means that instead of 'stasis', which we can reformulate here as physical states, it is'flux' that is the fundamental driving factor of change in physical states. Regarding that the the factors driving natural changes are the most fundamental laws of Nature, and, as we argued above, these are the first principles of physics and biology, this means that these first principles are more fundamental than observable phenomena and objects. We can obtain some further insights into the relation between physics and biology, physical matter and life.

In this paper, we found that initiating a biological process starts by a purely biological act that precedes physical processes. As Michael Polanyi (1968) argued, life harnesses the physical laws controlling the physical processes. We add that biological teleology can be regarded as an extension of the physical, mechanical teleology. While in physical teleology the endpoint is determined by the boundary and initial conditions on the basis of physical laws, ultimately, by the least action principle, in biology, the endpoint is determined by the greatest action principle (Grandpierre 2007) together with the autonomous decision of the living organism itself. With the help of an example, a bird dropped from the Pisa tower in the extended version of the Galileo experiment will not fall down freely as a stone or a dead bird. Instead, in the absence of any other biological aims, it will approximately regain its height, investing the minimal amount of energy, obeying to the greatest action principle, securing its vitality. Yet there is an infinitely large number of biologically equivalent endpoints corresponding to the same height. Therefore it is the bird itself that decides which to select. Once the bird itself decides the direction of its flight, on the basis of the greatest action principle, the endpoint becomes fixed; and so the physical principle of the least action becomes relevant. Indeed, the greatest action principle tells the bird, if we express ourselves in a somewhat simplified form, to live as long as possible with as much energy as possible. Therefore, once the endpoint is determined in accordance to the greatest action principle, the bird must apply the least action principle to realize the already fixed endpoint. Thus we obtain this result: The biological principle logically precedes the physical principle.

This means, on the one hand, that one of the basic characteristics of biological teleology is that it corresponds to the biologically autonomous decisions of living organisms themselves. On the other hand, our result indicates that in a biological process it is the biological principle, together with the biologically autonomous decsions, that acts first, and the physical actions only follow the biological decisions as secondary events. In light of the fact that the physical actions are already determined by the physical conditions on the basis of physical laws in the realm where physical determinism prevails, the biological decisions must correspond to the physically indeterminate realm. That is, at or below the quantum level. Considering that in quantum physics the vacuum effects are random, while biological actions are not random, we obtain a result that biological actions must start from below the quantum level, from a layer of Nature where the requirement of randomness does not apply. This means that the level of biologically autonomous decisions is below the quantum level. Thus we discover, for the first time, a deeper level of Nature beyond the quantum level: the biological level. This achievement has fundamental consequences.

If biology is more fundamental than physics, then there is no need to 'naturalize' (i.e., 'physicalize') teleology and biological autonomy. This circumstance offers an inference of first importance for us: *If biology is more fundamental than physics, then it is not necessary to explain the origin of life within the physicalist framework.*

3.4 From acausality to free will: a natural shift

It is important to be aware that there are three basic conceptual frameworks and corresponding mental toolkits by which to consider the problems of determinism, 'acausality', autonomy and 'free will'. In the first and narrowest conceptual framework, corresponding to strict physical (Laplacian) determinism, only physically determined processes are available as tools of explanation. In such a narrow context, the spontaneous quantum processes must arise acausally since there are no physically determined processes to explain phenomena such as spontaneous radioactive decay. In a somewhat wider context that includes vacuum processes, radioactive decay can be explained by spontaneous vacuum processes. In that second context, the apparent 'acausality' (indeterminacy) is shifted from radioactive decay to vacuum fluctuations. In this paper, we attempt to outline a novel, third, even wider context, in which vacuum processes can be initiated by biological autonomy, since, as we argued here, biologically initiated vacuum processes are also available as tools of explanation. In this widest, biological context the apparent 'acausality' is shifted from vacuum processes to biological autonomy. Indeed, 'acausality', or, more precisely, physical and biological indeterminacy is the characteristic property of biological autonomy, leading to an unexpectedly simple and natural explanation of 'free will'. Indeed, the 'acausal' decisions of living organisms are physically and biologically not completely pre-determined — that is to say free, to a certain extent. We point out that to understand biological autonomy and consciousness requires a mental shift from the narrowest Laplacian mental toolkit of classical physical determinism, through the conceptual framework of quantum physics to the widest, biological context of actual reality.

3.5 How is biological meaning attached?

We are considering now the cosmic genesis of cellular life, more precisely, the cosmic genesis of the first, protein-based cellular life form. Before the existence of such a cell, there were only atoms and molecules present, in their physico-chemical states, without biological functions. Biological functions always refer to the organism as a whole (Beckner 1969). Therefore, before the existence of the first cell as a whole, cellular biological functions could not exist. This means that the protein molecule, if it existed before the existence of the first cell, cannot have the biological function e.g. to defend the cell from germs.

Certainly, the function of e.g., proteins cannot arise by chance in the course of evolution, since evolution can select only the living organism as a whole, but cannot attach physically arbitrary rules assigning biological aims to biomolecules within cells. The number of biological functions of biomolecules is vast, and these functions by their very nature do not show a general, simple correspondence with their physical or biological properties; the relation between them is physically arbitrary at a certain degree. Fundamental laws of Nature contain a few variables only, and they, being laws, constitute the same relation between the corresponding properties in all cases. It follows that the biological functions cannot be attributed to each of these biomolecules on the basis of biological laws alone.

Our results show that biological functions cannot be assigned to their host biomolecules on the basis of physical or biological laws. Moreover, we have seen that the first cell cannot assign these functions either, because the existence of such functions is the precondition of the existence of the first cell. The problem, apparently, involves a kind of circularity: Biological functions of the components of cells can be assigned only by their host cell, but the first cell cannot arise without these functions being already assigned.

We propose a novel solution to solve this *problem of circularity*. The biological functions must be assigned indeed by an inclusive, host living organism; but this host organism cannot be the first living cell, but must be another, more inclusive, cosmic life form. On the basis of Bauer's principle, we have explored the idea that, alongside protein-based cellular life forms, other more general types of life forms may also exist in the vast Universe, such as plasma-based stellar life forms, intermittent life, microlife and the vacuum itself (Grandpierre 2008b). This latter, the cosmic vacuum, is an especially favorable candidate for fulfilling the task of assigning biological functions to the first cell, because it is not only more inclusive, involving in itself all biomolecules, but also because its existence precedes the existence of biomolecules. If so, then the relation between the cosmic vacuum and the functioning first cells is similar to that of a mother and her foetus, since the mother involves the foetus in her organism, and the existence of the mother precedes the conception of the foetus. In a sense, we can even say that the cosmic life form is what drives the functioning of the living cell. Therefore, by our proposal, it is the cosmic vacuum that acts as the 'soul' of all cellular and multicellular life forms. If this is the case, then it is not so much of a reach to say our soul is naturally attracted to the Cosmos; and this can explain the origin of cosmic sympathy as well as the

circumstance that “the soul is in the cosmos, and the cosmos is in the soul” (Tymieniecka 2011, 11).

3.6 Willpower beyond the quantum vacuum

How can the cosmic life form act, if not with the help of biological laws or Bauer’s principle? We find the solution in the concept of biological autonomy. Indeed, we argue that genuine biological autonomy is present in all living organisms (Grandpierre and Kafatos 2012; Grandpierre 2013). Biological autonomy is, in the cosmic context, the ultimate, cosmic subject, playing a fundamental role in the Cosmos that can be comparable to that of the laws of Nature. On the basis of our proposal, biologically autonomous decisions must be able to initiate vacuum processes that are, in the followings, suitable to govern and realize biological aims, triggering and coordinating physical processes according to the decisions made. This means that biologically autonomous decisions must occur from beyond the vacuum level itself. If this is the case, then the biologically autonmous decisions of living organisms would be even more subtle than the virtual processes of the quantum vacuum which are already the manifestations of these decisions. Certainly, subjective experience tells us that our autonomous self has a certain degree of energy, a kind of mental energy, like willpower, by which we can freely decide our actions.

3.7 Subjective tools capable to act on matter

We mention that more and more evidences have been accumulating indicating that it is possible to act on the physical states of living organisms by subjectively accessible tools of biological autonomy (*aims, beliefs, expectations, emotions, thoughts*) that are not really effective in the external world; and which are not restricted to the production of slight deviations from the physically expected changes (Miller 2011). It is known that beliefs and expectations (e.g., *placebo effect*) can markedly modulate neurophysiological and neurochemical activity (Beauregard 2009; Pollo, Carlino and Benedetti 2011; Meissner, Kohls and Colloca 2011). Neural correlates of *emotional states* such as sadness or depression have already been identified (Fortier et al. 2010), as well as measurable skin-conductance, heart rate and event-related potential changes (Balconi, Falbo and Conte 2012). It has been shown that emotions can induce secretion of hormones and thus influence behavior (Marin, Pilgrim and Lupien 2010; Martins et al. 2010). Rossi and Pourtois (2012) demonstrated that converging electrophysiological and brain-imaging results show that sensory processing in V1 can be modulated by *attention*. We think these facts indicate that living organisms actually have suitable subjective tools that are effective — through the occurrence of biologically initiated spontaneous vacuum processes — in acting on physical matter and producing physically measurable outcomes. If such subjective tools are already demonstrated to be effective in acting upon matter, and the material effectivity of free will is experimentally proved (Cerf and MacKay 2011), than autonomous decisions of living organisms can also be effective in a similar manner.

3.8 Higher dimensions and subjective world

Acknowledging the reality of the subjective tools of mind in shaping vacuum processes that are suitable to modify and govern physical processes within living organisms, we are led to a new and unprecedented picture describing the forces of the Cosmos and the cosmic genesis of life. In this new world picture, the Universe (to distinguish it from the physical universe, we capitalize it as Universe when it includes biological aspects, too) extends to a level “beyond” the quantum vacuum; it involves mental energies of cosmic life forms organized under such factors as decision making, attention, and biological aims. Moreover, since decision, attention and aims are tools of a biologically autonomous self, the utilization of such tools depends on the existence of a biologically autonomous self capable of deciding by itself, in a free decision; i.e., one not predetermined by physical, biological and psychological conditions and laws. This self is, as we argued above, beyond the cosmic quantum vacuum, therefore it does not exist in physical space and time. Thus it can be regarded as a cosmic self transcending the already familiar 3+1 spatio-temporal dimensions. Research on the nature of time (Saniga 1996, 1998, 2000, 2005) strongly underpins, using detailed mathematical descriptions and their empirical substantiations, that our 3+1 dimensional physical world is but one part of the whole mathematically describable mental reality existing in a multitude of higher spaces that serve as the framework of experiences in the corresponding mental states, and our mind is capable of switching between these spaces.

3.9 Transforming autonomous decisions to biological and physical forces

We are now able to formulate a fundamental enigma present in every biological action: How is biological action possible? How can something as ‘immaterial’ as a biological aim or purpose become transformed into physical forces capable of causing actual physical changes? How can a cell move itself? How can we move our arm? Without doubt, our arm can move at will. Apparently, our decision is not effective moving physical objects external to our organism; yet, within our organism, it can. Since our arm is, at least in a certain sense, a physical object, we can say that a physical object can be moved at will. It sounds something like magic - at the same time, we know that our arm cannot be moved in the absence of physical forces. This means that our decision must be transformed somehow into a physical force capable of moving our arm.

Our solution offered here suggests an unprecented solution that solves the mind-body problem. There must be biological causes beyond physical causes. The physical world is not closed, it is not restricted to physical causes only, but, through the quantum door of indeterminism, it is open to biological causes as well. Our solution proposes that our will (more concretely, our genuine biological decisions) cannot move physical objects directly, but it can move physical objects indirectly — with the help of one and only one tool: by the mediation of quantum vacuum processes that are initiated by our decisions. This unique achievement is possible only because our living organism is unified by biological organization in such a way that every part of it is coupled to the whole organism. Therefore, if our decision acts at the global, organismal level, then, utilizing the whole dynamic network of biological couplings, it can exert effects to each of its coupled subsystems by initiating quantum vacuum processes that interact with the matter

of our body in a systematic and organized manner. Indeed, it has been well known since the advent of quantum electrodynamics that all the physical forces can be described as exchange fluxes of virtual particles generated from the quantum vacuum by the physical laws. Our explanation of the mind-body problem makes it reasonable why such effects can occur regularly and systematically within living organisms.

3.10 Interaction between our self and the cosmic life form

Since the results presented here tell that our will can act on our body only through the quantum vacuum, which is organized as a cosmic life form (Grandpierre 2008b), then, inevitably, all our decisions have a cosmic context. This circumstance may have a central significance for shedding more light into the relation between life and the Cosmos. The mental energies utilized in our decisions may be regarded as creating and organizing new structures in the cosmic quantum vacuum. Therefore, there exist a next layer beyond the quantum vacuum, consisting of creative mental, subjectively accessible energies capable of organizing the quantum vacuum. Although this newly discovered layer of the Cosmos is found beyond the quantum vacuum, at the same time it is intimately connected with our innermost mentally accessible universe. The external and the internal universes show up as intimately related. Our personally accessible inner world has a fundamental relation to the cosmic quantum vacuum, to a mentally accessible, universal, cosmic dimension, which can act within us as a source of our inspirations, of our intuitive, creative energies, as the inexhaustible source of our personally accessible mental powers. Our result shows that cellular life did not originate from physical matter, or from physical laws, but in the interaction of the universal biological principle and cosmic biological autonomy with the organized cosmic life form, the biological quantum vacuum. Our naturally autonomous, physically undetermined, free self is itself shaping the cosmic dimensions, being rooted in the vast cosmic realm forming an interface with the quantum vacuum. We propose that this cosmic connection is what lies beyond the eternal call of the Cosmos, establishing a most personal contact between Homo Sapiens and the Universe.

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